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Community Considerations¹

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9.1 Community Acceptance

Community acceptance generally encompasses the planning, design, and construction phases of a substation as well as the in-service operation of the substation. It takes into account those issues that could influence a community's willingness to accept building a substation at a specific site. New substations or expansions of existing facilities often require extensive review for community acceptance. Government bodies typically require a variety of permits before construction may begin.

For community acceptance, several considerations should be satisfactorily addressed, including the following:

- Noise
- Site preparations
- Aesthetics
- Fire protection
- Potable water and sewage
- Hazardous materials
- Electric and magnetic fields
- Safety and security

¹Sections 3, 4, 5, 6, and 7 (excluding sections 4.3.2.2, 4.3.5, 4.4.2.1, 4.4.2.2, 4.4.2.3, 4.4.3.1, 4.4.3.2, 4.4.3.3, 4.4.3.4, 4.4.3.5, 5.1, 5.2, 6.1.4, 6.4, 7.2.1., 7.2.2, tables 1 and 2, and figures 1 and 2) reprinted from IEEE Std. 1127-1998, "IEEE Guide for the Design, Construction, and Operation of Electric Power Substations for Community Acceptance and Environmental Compatibility" Copyright ©1998, by the Institute of Electrical and Electronics Engineers, Inc. (IEEE). The IEEE disclaims any responsibility or liability resulting from the placement and use in the described manner. Information is reprinted with the permission of the IEEE.

This section on Community Considerations is essentially a condensed version of IEEE Standard 1127-1998.

9.2 Planning Strategies and Design

Planning is essential for the successful design, construction, and operation of a substation. The substation's location and proximity to wetlands, other sensitive areas, and contaminated soils; its aesthetic impact; and the concerns of nearby residents over noise and electric and magnetic fields (EMF) can significantly impact the ability to achieve community acceptance. Public perceptions and attitudes toward both real and perceived issues can affect the ability to obtain all necessary approvals and permits.

These issues can be addressed through presentations to governmental officials and the public. Failure to obtain community acceptance can delay the schedule or, in the extreme, stop a project completely.

9.2.1 Site Location and Selection, and Preparation

The station location (especially for new substations) is the key factor in determining the success of any substation project. Although the site location is based on electric system load growth studies, the final site location may ultimately depend upon satisfying the public and resolving potential community acceptance concerns. If necessary, a proactive public involvement program should be developed and implemented. The best substation site selection is influenced by several factors including, but not limited to, the following:

1. Community attitudes and perceptions
2. Location of nearby wetlands, bodies of water, or environmentally sensitive areas
3. Site contamination (obvious or hidden)
4. Commercial, industrial, and residential neighbors, including airports
5. Permit requirements and ordinances
6. Substation layout (including future expansions) and placement of noise sources
7. Levels of electric and magnetic fields
8. Availability and site clearing requirements for construction staging
9. Access to water and sewer
10. Drainage patterns and storm water management
11. Potential interference with radio, television, and other communication installations
12. Disturbance of archaeological, historical, or culturally significant sites
13. Underground services and geology
14. Accessibility
15. Aesthetic and screening considerations

9.2.1.1 Wetlands

A site-development plan is necessary for a substation project that borders wetlands. Such a plan for the site and its immediate surroundings should include the following:

1. Land-use description
2. Grades and contours
3. Locations of any wetland boundaries and stream-channel encroachment lines
4. Indication of flood-prone areas and vertical distance or access to ground water
5. Indication of existing wildlife habitats and migratory patterns

The plan should describe how site preparation will modify or otherwise impact these areas and what permanent control measures will be employed, including ground water protection.

9.2.1.2 Site Contamination

Soil borings should be taken on any proposed substation site to determine the potential presence of soil contaminants.

There are many substances that, if found on or under a substation site, would make the site unusable or require excessive funds to remediate the site before it would be usable. Some of the substances are as follows:

1. Polychlorinated biphenyls (PCBs)
2. Asbestos
3. Lead and other heavy metals
4. Pesticides and herbicides
5. Radioactive materials
6. Petrochemicals
7. Dioxin
8. Oil

Governmental guidelines for the levels of these substances should be used to determine if the substance is present in large enough quantities to be of concern.

The cost of removal and disposal of any contaminants should be considered before acquiring or developing the site. If a cleanup is needed, the acquisition of another site should be considered as governmental regulations can hold the current owner or user of a site responsible for cleanup of any contamination present, even if substances were deposited prior to acquisition. If a cleanup is initiated, all applicable governmental guidelines and procedures should be followed.

9.2.1.3 Potable Water and Sewage

The substation site may need potable water and sewage disposal facilities. Water may be obtained from municipal or cooperative water utilities or from private wells. Sewage may be disposed of by municipal services or septic systems, or the site could be routinely serviced by portable toilet facilities, which are often used during construction. Where municipal services are used for either water or sewer service, the requirements of that municipality must be met. Septic systems, when used, should meet all applicable local, state, and federal regulations.

9.2.2 Aesthetics

Aesthetics play a major role where community acceptance of a substation is an issue. Sites should be selected that fit into the context of present and future community patterns.

Community acceptability of a site can be influenced by:

1. Concerns about compatibility with present and future land uses
2. Building styles in the surrounding environment
3. Landscape of the site terrain
4. Allowance for buffer zones for effective blending, landscaping, and safety
5. Site access that harmonizes with the community

In addition, the site may need to be large enough to accommodate mobile emergency units and future expansions without becoming congested.

9.2.2.1 Visual Simulation

Traditionally, a site rendering was an artist's sketch, drawing, painting, or photomontage with airbrush retouching, preferably in color, and as accurate and realistic as possible. In recent years, these traditional techniques, although still employed, have given way to two- and three-dimensional computer-generated images, photorealism, modeling, and animation to simulate and predict the impact of proposed developments.

This has led to increased accuracy and speed of image generation in the portrayal of new facilities for multiple-viewing (observer) positions, allowing changes to be made early in the decision-making process while avoiding costly alterations that sometimes occur later during construction.

A slide library of several hundred slides of aesthetic design choices is available from the IEEE. It is a compilation of landscaping, decorative walls and enclosures, plantings, and site location choices that have been used by various utilities worldwide to ensure community acceptance and environmental compatibility.

9.2.2.2 Landscaping and Topography

Landscaping: Where buffer space exists, landscaping can be a very effective aesthetic treatment. On a site with little natural screening, plantings can be used in concert with architectural features to complement and soften the visual effect.

All plantings should be locally available and compatible types, and should require minimum maintenance. Their location near walls and fences should not compromise either substation grounding or the security against trespass by people or animals.

Topography: Topography or land form, whether shaped by nature or by man, can be one of the most useful elements of the site to solve aesthetic and functional site development problems.

Use of topography as a visual screen is often overlooked. Functionally, earth forms can be permanent, visual screens constructed from normal on-site excavating operations. When combined with plantings of grass, bushes, or evergreens and a planned setback of the substation, berms can effectively shield the substation from nearby roads and residents.

Fences and walls: The National Electrical Safety Code® [(NESC®) (Accredited Standards Committee C2-1997)] requires that fences, screens, partitions, or walls be employed to keep unauthorized persons away from substation equipment.

Chain-link fences: This type of fence is the least vulnerable to graffiti and is generally the lowest-cost option. Chain-link fences can be galvanized or painted in dark colors to minimize their visibility, or they can be obtained with vinyl cladding. They can also be installed with wooden slats or colored plastic strips woven into the fence fabric. Grounding and maintenance considerations should be reviewed before selecting such options.

Wood fences: This type of fence should be constructed using naturally rot-resistant or pressure-treated wood, in natural color or stained for durability and appearance. A wood fence can be visually overpowering in some settings. Wood fences should be applied with caution because wood is more susceptible to deterioration than masonry or metal.

Walls: Although metal panel and concrete block masonry walls cost considerably more than chain-link and wood fences, they deserve consideration where natural or landscaped screening does not provide a sufficient aesthetic treatment. Brick and precast concrete can also be used in solid walls, but these materials are typically more costly. These materials should be considered where necessary for architectural compatibility with neighboring facilities. Walls can offer noise reduction (discussed later) but can be subject to graffiti. All issues should be considered before selecting a particular wall or fence type.

9.2.2.3 Color

When substations are not well screened from the community, color can have an impact on the visual effect.

Above the skyline, the function of color is usually confined to eliminating reflective glare from bright metal surfaces. Because the sun's direction and the brightness of the background sky vary, no one color can soften the appearance of substation structures in the course of changing daylight. Below the skyline, color can be used in three aesthetic capacities. Drab coloring, using earth tones and achromatic hues, is a technique that masks the metallic sheen of such objects as chain-link fences and steel structures, and reduces visual contrast with the surrounding landscape. Such coloring should have very limited variation in hues, but contrast by varying paint saturation is often more effective than a monotone coating. Colors and screening can often be used synergistically. A second technique is to use color to direct visual attention to more aesthetically pleasing items such as decorative walls and enclosures. In this use, some brightness is warranted, but highly saturated or contrasting hues should be avoided. A third technique is to brightly color equipment and structures for intense visual impact.

9.2.2.4 Lighting

When attractive landscaping, decorative fences, enclosures, and colors have been used to enhance the appearance of a highly visible substation, it may also be appropriate to use lighting to highlight some of these features at night. Although all-night lighting can enhance substation security and access at night, it should be applied with due concern for nearby residences.

9.2.2.5 Structures

The importance of aesthetic structure design increases when structures extend into the skyline. The skyline profile typically ranges from 6 m to 10 m (20 ft to 35 ft) above ground. Transmission line termination structures are usually the tallest and most obvious. Use of underground line exits will have the greatest impact on the substation's skyline profile. Where underground exits are not feasible, low-profile station designs should be considered. Often, low-profile structures will result in the substation being below the nearby tree line profile.

For additional cost, the most efficient structure design can be modified to improve its appearance. The following design ideas may be used to improve the appearance of structures:

1. Tubular construction
2. Climbing devices not visible in profile
3. No splices in the skyline zone
4. Limiting member aspect ratio for slimmer appearance
5. Use splices other than pipe-flange type
6. Use of gusset plates with right-angle corners not visible in profile
7. Tapering ends of cantilevers
8. Equal length of truss panel
9. Making truss diagonals with an approximate 60° angle to chords
10. Use of short knee braces or moment-resistant connections instead of full-height diagonal braces
11. Use of lap splice plates only on the insides of H-section flanges

9.2.2.6 Enclosures

Total enclosure of a substation within a building is an option in urban settings where underground cables are used as supply and feeder lines. Enclosure by high walls, however, may be preferred if enclosure concealment is necessary for community acceptance.

A less costly design alternative in nonurban locales that are served by overhead power lines is to take advantage of equipment enclosures to modify visual impact. Relay and control equipment, station batteries, and indoor power switchgear all require enclosures. These enclosures can be aesthetically designed and strategically located to supplement landscape concealment of other substation equipment. The exterior appearance of these enclosures can also be designed (size, color, materials, shape) to match neighboring homes or buildings.

Industrial-type, pre-engineered metal enclosures are a versatile and economic choice for substation equipment enclosures. Concrete block construction is also a common choice for which special shaped and colored blocks may be selected to achieve a desired architectural effect. Brick, architectural metal panels, and precast concrete can also be used.

Substation equipment enclosures usually are not exempt from local building codes. Community acceptance, therefore, requires enclosure design, approval, and inspection in accordance with local regulation.

9.2.2.7 Bus Design

Substations can be constructed partly or entirely within aboveground or belowground enclosures. However, cost is high and complexity is increased by fire-protection and heat-removal needs. The following discussion deals with exposed aboveground substations.

Air-insulated substations: The bus and associated substation equipment are exposed and directly visible. An outdoor bus may be multitiered or spread out at one level. Metal or wood structures and insulators support such bus and power line terminations. Space permitting, a low-profile bus layout is generally best for aesthetics and is the easiest to conceal with landscaping, walls, and enclosures. Overhead transmission line terminating structures are taller and more difficult to conceal in such a layout. In dry climates, a low-profile bus can be achieved by excavating the earth area, within which outdoor bus facilities are then located for an even lower profile.

Switchgear: Metal-enclosed or metal-clad switchgear designs that house the bus and associated equipment in a metal enclosure are an alternative design for distribution voltages. These designs provide a compact low-profile installation that may be aesthetically acceptable.

Gas-insulated substation (GIS): Bus and associated equipment can be housed within pipe-type enclosures using sulfur hexafluoride or another similar gas for insulation. Not only can this achieve considerable compactness and reduced site preparation for higher voltages, but it can also be installed lower to the ground. A GIS can be an economically attractive design where space is at a premium, especially if a building-type enclosure will be used to house substation equipment (see IEEE Std. C37.123-1996).

Cable bus: Short sections of overhead or underground cables can be used at substations, although this use is normally limited to distribution voltages (e.g., for feeder getaways or transformer-to-switchgear connections). At higher voltages, underground cable can be used for line-entries or to resolve a specific connection problem.

9.2.3 Noise

Audible noise, particularly continuously radiated discrete tones (e.g., from power transformers), is the type of noise that the community may find unacceptable. Community guidelines to ensure that acceptable noise levels are maintained can take the form of governmental regulations or individual/community reaction (permit denial, threat of complaint to utility regulators, etc.). Where noise is a potential concern, field measurements of the area background noise levels and computer simulations predicting the impact of the substation may be required. The cost of implementing noise reduction solutions (low-noise equipment, barriers or walls, noise cancellation techniques, etc.) may become a significant factor when a site is selected.

Noise can be transmitted as a pressure wave either through the air or through solids. The majority of cases involving the observation and measurement of noise have dealt with noise being propagated through the air. However, there are reported, rare cases of audible transformer noise appearing at distant observation points by propagating through the transformer foundation and underground solid rock formations. It is best to avoid the situation by isolating the foundation from bedrock where the conditions are thought to favor transmission of vibrations.

9.2.3.1 Noise Sources

Continuous audible sources: The most noticeable audible noise generated by normal substation operation consists of continuously radiated audible discrete tones. Noise of this type is primarily generated by power transformers. Regulating transformers, reactors, and emergency generators, however, could also be sources. This type of noise is most likely to be subject to government regulations. Another source of audible noise in substations, particularly in extra high voltage (EHV) substations, is corona from the bus and conductors.

Continuous radio frequency (RF) sources: Another type of continuously radiated noise that can be generated during normal operation is RF noise. These emissions can be broadband and can cause interference to radio and television signal reception on properties adjacent to the substation site. Objectionable RF noise is generally a product of unintended sparking, but can also be produced by corona.

Impulse sources: While continuously radiated noise is generally the most noticeable to substation neighbors, significant values of impulse noise can also accompany normal operation. Switching operations will cause both impulse audible and RF noise with the magnitude varying with voltage, load, and operation speed. Circuit-breaker operations will cause audible noise, particularly operation of air-blast breakers.

9.2.3.2 Typical Noise Levels

Equipment noise levels: Equipment noise levels may be obtained from manufacturers, equipment tendering documents, or test results. The noise level of a substation power transformer is a function of the MVA and BIL rating of the high voltage winding. These transformers typically generate a noise level ranging from 60 to 80 dBA.

Transformer noise will “transmit” and attenuate at different rates depending on the transformer size, voltage rating, and design. Few complaints from nearby residents are typically received concerning substations with transformers of less than 10 MVA capacity, except in urban areas with little or no buffers. Complaints are more common at substations with transformer sizes of 20–150 MVA, especially within the first 170–200 m (500–600 ft). However, in very quiet rural areas where the nighttime ambient can reach 20–25 dBA, the noise from the transformers of this size can be audible at distances of 305 m (1000 ft) or more. In urban areas, substations at 345 kV and above rarely have many complaints because of the large parcels of land on which they are usually constructed.

Attenuation of noise with distance: The rate of attenuation of noise varies with distance for different types of sound sources depending on their characteristics. Point sound sources that radiate equally in all directions will decrease at a rate of 6 dB for each doubling of distance. Cylindrical sources vibrating uniformly in a radial direction will act like long source lines and the sound pressure will drop 3 dB for each doubling of distance. Flat planar surfaces will produce a sound wave with all parts of the wave tracking in the same direction (zero divergence). Hence, there will be no decay of the pressure level due to distance only. The designer must first identify the characteristics of the source before proceeding with a design that will take into account the effect of distance.

A transformer will exhibit combinations of all of the above sound sources, depending on the distance and location of the observation point. Because of its height and width, which can be one or more wavelengths, and its nonuniform configuration, the sound pressure waves will have directional characteristics with very complex patterns. Close to the transformer (near field), these vibrations will result in lobes with variable pressure levels. Hence, the attenuation of the noise level will be very small. If the width (W) and height (H) of the transformer are known, then the near field is defined, from observation, as any distance less than $2\sqrt{WH}$ from the transformer.

Further from the transformer (far field), the noise will attenuate in a manner similar to the noise emitted from a point source. The attenuation is approximately equal to 6 dB for every doubling of the distance. In addition, if a second adjacent transformer produces an identical noise level to the existing transformer (e.g., 75 dBA), the total sound will be 78 dBA for a net increase of only 3 dB. This is due to the logarithmic effect associated with a combination of noise sources.

9.2.3.3 Governmental Regulations

Governmental regulations may impose absolute limits on emissions, usually varying the limits with the zoning of the adjacent properties. Such limits are often enacted by cities, villages, and other incorporated urban areas where limited buffer zones exist between property owners. Typical noise limits at the substation property line used within the industry are as follows:

- Industrial zone < 75 dBA
- Commercial zone < 65 dBA
- Residential zone < 55 dBA

Additional governmental noise regulations address noise levels by limiting the increase above the existing ambient to less than 10 dB. Other regulations could limit prominent discrete tones, or set specific limits by octave bands.

9.2.3.4 Noise Abatement Methods

The likelihood of a noise complaint is dependent on several factors, mostly related to human perceptions. As a result, the preferred noise abatement method is time-dependent as well as site-specific.

Reduced transformer sound levels: Since power transformers, voltage regulators, and reactors are the primary sources of continuously radiated discrete tones in a substation, careful attention to equipment design can have a significant effect on controlling noise emissions at the substation property line. This equipment can be specified with noise emissions below manufacturers' standard levels, with values as much as 10 dB below those levels being typical.

In severely restrictive cases, transformers can be specified with noise emissions 20 dB less than the manufacturers' standard levels, but usually at a significant increase in cost. Also, inclusion of bid evaluation factor(s) for reduced losses in the specification can impact the noise level of the transformer. Low-loss transformers are generally quieter than standard designs.

Low-impulse noise equipment: Outdoor-type switching equipment is the cause of most impulse noise. Switchgear construction and the use of vacuum or puffer circuit breakers, where possible, are the most effective means of controlling impulse emissions. The use of circuit switchers or air-break switches with whips and/or vacuum bottles for transformer and line switching, may also provide impulse-emission reductions over standard air-break switches.

RF noise and corona-induced audible noise control: Continuously radiated RF noise and corona-induced audible noise can be controlled through the use of corona-free hardware and shielding for high-voltage conductors and equipment connections, and through attention to conductor shapes to avoid sharp corners. Angle and bar conductors have been used successfully up to 138 kV without objectionable corona if corners are rounded at the ends of the conductors and bolts are kept as short as possible.

Tubular shapes are typically required above this voltage. Pronounced edges, extended bolts, and abrupt ends on the conductors can cause significant RF noise to be radiated. The diameter of the conductor also has an effect on the generation of corona, particularly in wet weather. Increasing the size of single grading rings or conductor diameter may not necessarily solve the problem. In some cases it may be better to use multiple, smaller diameter grading rings.

Site location: For new substations to be placed in an area known to be sensitive to noise levels, proper choice of the site location can be effective as a noise abatement strategy. Also, locations in industrial parks or near airports, expressways, or commercial zones that can provide almost continuous background noise levels of 50 dB or higher will minimize the likelihood of a complaint.

Larger yard area: Noise intensity varies inversely with distance. An effective strategy for controlling noise of all types involves increasing the size of the parcel of real estate on which the substation is located.

Equipment placement: Within a given yard size, the effect of noise sources on the surroundings can be mitigated by careful siting of the noise sources within the confines of the substation property. In addition, making provisions for the installation of mobile transformers, emergency generators, etc. near the center of the property, rather than at the edges, will lessen the effect on the neighbors.

Barriers or walls: If adequate space is not available to dissipate the noise energy before it reaches the property line, structural elements might be required. These can consist of walls, sound-absorbing panels, or deflectors. In addition, earth berms or below-grade installation may be effective. It may be possible to deflect audible noises, especially the continuously radiated tones most noticeable to the public, to areas not expected to be troublesome. Foliage, despite the potential aesthetic benefit and psychological effect, is not particularly effective for noise reduction purposes.

Properly constructed sound barriers can provide several decibels of reduction in the noise level. An effective barrier involves a proper application of the basic physics of:

1. Transmission loss through masses
2. Sound diffraction around obstacles
3. Standing waves behind reflectors
4. Absorption at surfaces

For a detailed analysis of wall sound barriers, refer to IEEE Std. 1127-1998.

Active noise cancellation techniques: Another solution to the problem of transformer noise involves use of active noise control technology to cancel unwanted noise at the source, and is based on advances

in digital controller computer technology. Active noise cancellation systems can be tuned to specific problem frequencies or bands of frequencies achieving noise reduction of up to 20 dB.

9.2.4 Electric and Magnetic Fields

Electric substations produce electric and magnetic fields. In a substation, the strongest fields around the perimeter fence come from the transmission and distribution lines entering and leaving the substation. The strength of fields from equipment inside the fence decreases rapidly with distance, reaching very low levels at relatively short distances beyond substation fences.

In response to the public concerns with respect to EMF levels, whether perceived or real, and to governmental regulations, the substation designer may consider design measures to lower EMF levels or public exposure to fields while maintaining safe and reliable electric service.

9.2.4.1 Electric and Magnetic Field Sources in a Substation

Typical sources of electric and magnetic fields in substations include the following:

1. Transmission and distribution lines entering and exiting the substation
2. Buswork
3. Transformers
4. Air core reactors
5. Switchgear and cabling
6. Line traps
7. Circuit breakers
8. Ground grid
9. Capacitors
10. Battery chargers
11. Computers

9.2.4.2 Electric Fields

Electric fields are present whenever voltage exists on a conductor. Electric fields are not dependent on the current. The magnitude of the electric field is a function of the operating voltage and decreases with the square of the distance from the source. The strength of an electric field is measured in volts per meter. The most common unit for this application is kilovolts per meter. The electric field can be easily shielded (the strength can be reduced) by any conducting surface such as trees, fences, walls, buildings, and most structures. In substations, the electric field is extremely variable due to the screening effect provided by the presence of the grounded steel structures used for electric bus and equipment support.

Although the level of the electric fields could reach magnitudes of approximately 13 kV/m in the immediate vicinity of high-voltage apparatus, such as near 500-kV circuit breakers, the level of the electric field decreases significantly toward the fence line. At the fence line, which is at least 6.4 m (21 ft) from the nearest live 500-kV conductor (see the NESC), the level of the electric field approaches zero kV/m. If the incoming or outgoing lines are underground, the level of the electric field at the point of crossing the fence is negligible.

9.2.4.3 Magnetic Fields

Magnetic fields are present whenever current flows in a conductor, and are not voltage dependent. The level of these fields also decreases with distance from the source but these fields are not easily shielded. Unlike electric fields, conducting materials such as the earth, or most metals, have little shielding effect on magnetic fields.

Magnetic fields are measured in Webers per square meter (Tesla) or Maxwells per square centimeter (Gauss). One Gauss = 10^{-4} Tesla. The most common unit for this application is milliGauss (10^{-3} Gauss).

Various factors affect the levels of the fields, including the following:

1. Current magnitude
2. Phase spacing
3. Bus height
4. Phase configurations
5. Distance from the source
6. Phase unbalance (magnitude and angle)

Magnetic fields decrease with increasing distance (r) from the source. The rate is an inverse function and is dependent on the type of source. For point sources such as motors and reactors, the function is $1/r^2$; and for single-phase sources such as neutral or ground conductors the function is $1/r$. Besides distance, conductor spacing and phase balance have the largest effect on the magnetic field level because they control the rate at which the field changes.

Magnetic fields can sometimes be shielded by specially engineered enclosures. The application of these shielding techniques in a power system environment is minimal because of the substantial costs involved and the difficulty of obtaining practical designs.

9.2.5 Safety and Security

9.2.5.1 Fences and Walls

The primary means of ensuring public safety at substations is by the erection of a suitable barrier, such as a fence or a wall with warning signs. As a minimum, the barrier should meet the requirements of the NESC and other applicable electrical safety codes. Recommended clearances from substation live parts to the fence are specified in the NESC, and security methods are described in IEEE P1402/D8.

9.2.5.2 Lighting

Yard lighting may be used to enhance security and allow equipment status inspections. A yard-lighting system should provide adequate ground-level lighting intensity around equipment and the control-house area for security purposes without disruption to the surrounding community. High levels of nightly illumination will often result in complaints.

9.2.5.3 Grounding

Grounding should meet the requirement of IEEE Std. 80-1986 to ensure the design of a safe and adequate grounding system. All noncurrent-carrying metal objects in or exiting from substations should be grounded (generally to a buried metallic grid) to eliminate the possibility of unsafe touch or step potentials, which the general public might experience during fault conditions.

9.2.5.4 Fire Protection

The potential for fires exists throughout all stations. Although not a common occurrence, substation fires are an important concern because of potential for long-term outages, personnel injury or death, extensive property and environmental damage, and rapid uncontrolled spreading. Refer to IEEE Std. 979-1994 for detailed guidance and identification of accepted substation fire-protection design practices and applicable industry standards.

9.3 Permitting Process

A variety of permits may be required by the governing bodies before construction of a substation may begin. For the permitting process to be successful, the following factors may have to be considered:

1. Site location
2. Level of ground water
3. Location of wetlands
4. Possibility of existing hazardous materials

5. Need for potable water and sewage
6. Possible noise
7. Aesthetics
8. EMF

Timing for the permit application is a critical factor because the permit application may trigger opposition involvement. If it is determined that the situation requires public involvement, the preparation and implementation of a detailed plan using public participation can reduce the delays and costs associated with political controversy and litigation. In these situations, public involvement prior to permit application can help to build a positive relationship with those affected by the project, identify political and community concerns, obtain an informed consensus from project stakeholders, and provide a basis for the utility to increase its credibility and reputation as a good neighbor.

9.4 Construction

9.4.1 Site Preparation

9.4.1.1 Clearing, Grubbing, Excavation, and Grading

Concerns include the creation of dust, mud, water runoff, erosion, degraded water quality, and sedimentation. The stockpiling of excavated material and the disposal of excess soil, timber, brush, etc. are additional items that should be considered. Protective measures established during the design phase or committed to through the permitting process for ground water, wetlands, flood plains, streams, archeological sites, and endangered flora and fauna should be implemented during this period.

9.4.1.2 Site Access Roads

The preparation and usage of site access roads create concerns that include construction equipment traffic, dust, mud, water runoff, erosion, degraded water quality, and sedimentation. Access roads can also have an impact on agriculture, archaeological features, forest resources, wildlife, and vegetation.

9.4.1.3 Water Drainage

Runoff control is especially important during the construction process. Potential problems include flooding, erosion, sedimentation, and waste and trash carried off the site.

9.4.2 Noise

Noise control is important during construction in areas sensitive to this type of disturbance. An evaluation should be made prior to the start of construction to determine noise restrictions that may be imposed at the construction site.

9.4.3 Safety and Security

Safety and security procedures should be implemented at the outset of the construction process to protect the public and prevent unauthorized access to the site. These procedures should be developed in conformance with governmental agencies. See IEEE P1402/D8 for detailed descriptions of the security methods that can be employed. The safety and security program should be monitored continuously to ensure that it is functioning properly.

The following are suggestions for safety and security at the site:

1. Temporary or permanent fencing
2. Security guards
3. Security monitoring systems
4. Traffic control

5. Warning signs
6. Construction safety procedures
7. Temporary lighting

9.4.4 Site Housekeeping

During construction, debris and refuse should not be allowed to accumulate. Efforts should be made to properly store, remove, and prevent these materials from migrating beyond the construction site. Burning of refuse should be avoided. In many areas this activity is prohibited by law. Portable toilets that are routinely serviced should be provided.

9.4.5 Hazardous Material

The spillage of transformer and pipe cable insulating oils, paints, solvents, acids, fuels, and other similar materials can be detrimental to the environment as well as a disturbance to the neighborhood. Proper care should be taken in the storage and handling of such materials during construction.

9.5 Operations

9.5.1 Site Housekeeping

Water and sediment control: Routine inspection of control for water flows is important to maintain proper sediment control measures. Inspection should be made for basin failure and for gullies in all slopes. Inspection of all control measures is necessary to be sure that problems are corrected as they develop and should be made a part of regular substation inspection and maintenance.

Yard surface maintenance: Yard surfacing should be maintained as designed to prevent water runoffs and control dust. If unwanted vegetation is observed on the substation site, approved herbicides may be used with caution to prevent runoff from damaging surrounding vegetation. If runoffs occur, the affected area should be covered with stone to retard water runoff and to control dust.

Paint: When material surfaces are protected by paint, a regular inspection and repainting should be performed to maintain a neat appearance and to prevent corrosion damage.

Landscaping: Landscaping should be maintained to ensure perpetuation of design integrity and intent.

Storage: In some areas, zoning will not permit storage in substations. The local zoning must therefore be reviewed before storing equipment, supplies, etc. The appearance of the substation site should be considered so it will not become visually offensive to the surrounding community.

Noise: Inspection of all attributes of equipment designed to limit noise should be performed periodically.

Safety and security: All substations should be inspected regularly, following established and written procedures to ensure the safety and security of the station. Safe and secure operation of the substation requires adequate knowledge and proper use of each company's accident prevention manual. See IEEE P1402/D8 for detailed descriptions of the security methods that can be employed.

Routine inspections of the substation should be performed and recorded, and may include the following:

1. Fences
2. Gates
3. Padlocks
4. Signs
5. Access detection systems
6. Alarm systems
7. Lighting systems

8. Grounding systems
9. Fire-protection equipment
10. All oil-filled equipment
11. Spill-containment systems

9.5.2 Fire Protection

Refer to IEEE Std. 979-1994 for detailed guidance and identification of accepted substation fire-protection practices and applicable industry standards. Any fire-protection prevention system installed in the substation should be properly maintained.

9.5.3 Hazardous Material

A spill-prevention control and countermeasures plan should be in place for the substation site and should meet governmental requirements. For general guidance, see IEEE Std. 980-1994.

9.6 Defining Terms (IEEE, 1998)

A-weighted sound level: The representation of the sound pressure level that has as much as 40 dB of the sound below 100 Hz and a similar amount above 10,000 Hz filtered out. This level best approximates the response of the average young ear when listening to most ordinary, everyday sounds. Generally designated as dBA.

Commercial zone: A zone that includes offices, shops, hotels, motels, service establishments, or other retail/commercial facilities as defined by local ordinances.

Hazardous material: Any material that has been so designated by governmental agencies or adversely impacts human health or the environment.

Industrial zone: A zone that includes manufacturing plants where fabrication or original manufacturing is done, as defined by local ordinances.

Noise: Undesirable sound emissions or undesirable electromagnetic signals/emissions.

Residential zone: A zone that includes single-family and multifamily residential units, as defined by local ordinances.

Wetlands: Any land that has been so designated by governmental agencies. Characteristically, such land contains vegetation associated with saturated types of soil.

For additional definitions, see IEEE Std. 100-1996.

References

Guide for Electric Power Substation Physical and Electronic Security, IEEE P1402/D8, draft dated April 1997.²
IEEE Guide for the Design, Construction, and Operation of Electric Power Substations for Community Acceptance and Environmental Compatibility, IEEE Std. 1127-1998.

IEEE Guide for Safety in AC Substation Grounding, IEEE Std. 80-1991.

IEEE Guide to Specifications for Gas-Insulated, Electric Power Substation Equipment, IEEE Std C37.123-1996.

IEEE Guide for Substation Fire Protection, IEEE Std. 979-1994.

The IEEE Standard Dictionary of Electrical and Electronics Terms, IEEE Std. 100-1996.

IEEE Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields from AC Power Lines, IEEE Std. 644-1994.

National Electrical Safety Code® (NESC®) (ANSI), Accredited Standards Committee C2-1997, Institute of Electrical Electronics Engineers, Piscataway, NJ, 1997.

²This IEEE standards project was not approved by the IEEE Standards Board at the time this publication went to press. For information about obtaining a draft, contact the IEEE.